

What is claimed is:

1. A computer implemented method of analyzing a signal
5 comprising:
 inputting the signal;
 extracting a set of Intrinsic Mode Functions from the
signal; and
 generating a set of mean frequency functions from the
10 Intrinsic Mode Functions.
2. The computer implemented method as in claim 1 further
comprising: the step of summing up the mean frequency functions.
- 15 3. The computer implemented method as in claim 2 further
comprising the step of:
 displaying the sum of the mean frequency functions.
4. The computer implemented method as in claim 1, wherein the
20 step of generating a set of mean frequency functions comprises:
 computing the mean frequency at a point along the time
scale for one of the Intrinsic Mode Functions; and
 continuing to perform the computing step for all of the
Intrinsic Mode Functions.
- 25 5. The computer implemented method as in claim 4, wherein the
mean frequency at a point under consideration is defined as
follows:
$$\varpi = \frac{1}{12} \left\{ \frac{1}{T_4} + \left(\frac{1}{T_2^1} + \frac{1}{T_2^2} \right) + \left(\frac{1}{T_1^1} + \frac{1}{T_1^2} + \frac{1}{T_1^3} + \frac{1}{T_1^4} \right) \right\}$$

30 wherein
 ϖ is mean frequency;

T_1^x is full periods ($x = 1, 2, 3,$ and 4) enclosing the point under consideration;

T_2^y is half periods ($y = 1$ and 2) enclosing the point under consideration; and

T_4 is a quarter period enclosing the point under consideration;

6. The computer implemented method as in claim 4, wherein the mean frequency at a point under consideration is defined as follows:

$$5 \quad \varpi = \frac{1}{7} \left\{ \frac{1}{4T_4} + \left(\frac{1}{2T_2^1} + \frac{1}{2T_2^2} \right) + \left(\frac{1}{T_1^1} + \frac{1}{T_1^2} + \frac{1}{T_1^3} + \frac{1}{T_1^4} \right) \right\}$$

wherein

ϖ is mean frequency;

T_1^x is full periods ($x = 1, 2, 3,$ and 4) enclosing the point under consideration;

T_2^y is half periods ($y = 1$ and 2) enclosing the point under consideration; and

T_4 is a quarter period enclosing the point under consideration;

7. The computer implemented method as in claim 1, wherein extracting a set of Intrinsic Mode Functions from the signal comprises:

recursively sifting the signal via Empirical Mode Decomposition to extract an intrinsic mode function indicative of an intrinsic oscillatory mode;

15 generating a residual signal by subtracting the intrinsic mode function from the signal;

treating the residual signal as the signal during a next iteration of said recursive sifting step; and

iterating to perform said recursive sifting to generate an

n-th intrinsic mode function indicative of an n-th intrinsic oscillatory mode until a stopping condition is met.

8. The computer implemented method of analyzing a signal according to claim 7, wherein said recursive sifting including:

identifying local maximum values in the signal;
constructing an upper envelope of the signal from the identified local maximum values;

10 identifying local minimum values in the signal;
constructing a lower envelope of the signal from the identified local minimum values;

determining an envelope mean from the upper and lower envelopes;

15 generating a component signal by subtracting the envelope mean from the signal;

treating the component signal as the signal; and
recursively performing said sifting until successive component signals are substantially equal.

20 9. The computer implemented method of analyzing a signal according to claim 8, wherein the step of constructing a lower envelope of the signal includes connecting the identified local minimum values with straight lines; and the step of constructing an upper envelope of the signal includes connecting the identified local maximum values with straight lines.

10. The computer implemented method of analyzing a signal according to claim 8, wherein the step of constructing a lower envelope of the signal includes connecting the identified local minimum values with cubic spline fitting; and the step of constructing a upper envelope of the signal includes connecting

the identified local maximum values with cubic spline fitting.

11. A computer implemented method of analyzing a signal comprising:

- 5 inputting the signal; /
- extracting a set of Intrinsic Mode Functions from the signal; and
- generating instantaneous frequency based on critical points of the signal.

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12. The computer implemented method as in claim 11, wherein the step of generating instantaneous frequency based on critical points comprises:

- generating a set of mean frequency functions from the
- 15 Intrinsic Mode Functions.

13. The computer implemented method as in claim 12 further comprising: the step of summing up the mean frequency functions.

- 20 14. The computer implemented method as in claim 13 further comprising the step of:
- displaying the sum of the mean frequency functions.

15. The computer implemented method as in claim 12, wherein the
- 25 step of generating a set of mean frequency functions comprises:
- computing the mean frequency at a point along the time scale for one of the Intrinsic Mode Functions; and
- continuing to perform the computing step for all of the Intrinsic Mode Functions.

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16. The computer implemented method as in claim 15, wherein the mean frequency at a point under consideration is defined as

follows:

$$\varpi = \frac{1}{12} \left\{ \frac{1}{T_4} + \left(\frac{1}{T_1^1} + \frac{1}{T_2^2} \right) + \left(\frac{1}{T_1^1} + \frac{1}{T_1^2} + \frac{1}{T_1^3} + \frac{1}{T_1^4} \right) \right\}$$

wherein

ϖ is mean frequency;

T_1^x is full periods ($x = 1, 2, 3,$ and 4) enclosing the point under consideration;

T_2^y is half periods ($y = 1$ and 2) enclosing the point under consideration; and

T_4 is a quarter period enclosing the point under consideration;

- 5 17. The computer implemented method as in claim 15, wherein the mean frequency at a point under consideration is defined as follows:

$$\varpi = \frac{1}{7} \left\{ \frac{1}{4T_4} + \left(\frac{1}{2T_1^1} + \frac{1}{2T_2^2} \right) + \left(\frac{1}{T_1^1} + \frac{1}{T_1^2} + \frac{1}{T_1^3} + \frac{1}{T_1^4} \right) \right\}$$

wherein

ϖ is mean frequency;

T_1^x is full periods ($x = 1, 2, 3,$ and 4) enclosing the point under consideration;

T_2^y is half periods ($y = 1$ and 2) enclosing the point under consideration; and

T_4 is a quarter period enclosing the point under consideration;

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18. The computer implemented method as in claim 11, wherein extracting a set of Intrinsic Mode Functions from the signal comprises:

recursively sifting the signal via Empirical Mode

- 15 Decomposition to extract an intrinsic mode function indicative of an intrinsic oscillatory mode;

generating a residual signal by subtracting the intrinsic mode function from the signal;

treating the residual signal as the signal during a next iteration of said recursive sifting step; and

5 iterating to perform said recursive sifting to generate an n-th intrinsic mode function indicative of an n-th intrinsic oscillatory mode until a stopping condition is met.

19. The computer implemented method of analyzing a signal
10 according to claim 18, wherein said recursive sifting including:

identifying local maximum values in the signal;

constructing an upper envelope of the signal from the identified local maximum values;

15 identifying local minimum values in the signal;

constructing a lower envelope of the signal from the identified local minimum values;

determining an envelope mean from the upper and lower envelopes;

20 generating a component signal by subtracting the envelope mean from the signal;

treating the component signal as the signal; and

recursively performing said sifting until successive component signals are substantially equal.

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20. The computer implemented method of analyzing a signal according to claim 19, wherein the step of constructing a lower envelope of the signal includes connecting the identified local minimum values with straight lines; and the step of constructing
30 an upper envelope of the signal includes connecting the identified local maximum values with straight lines.

21. The computer implemented method of analyzing a signal according to claim 19, wherein the step of constructing a lower envelope of the signal includes connecting the identified local minimum values with cubic spline fitting; and the step of
5 constructing a upper envelope of the signal includes connecting the identified local maximum values with cubic spline fitting.